

UNITED STATES PATENT APPLICATION

TRANSMIT POWER CONTROL WITHIN A WIRELESS TRANSMITTER

INVENTOR

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TRANSMIT POWER CONTROL WITHIN A WIRELESS TRANSMITTER

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FIELD OF THE INVENTION

The invention relates generally to wireless communication systems and, more particularly, to power control techniques for use therein.

BACKGROUND OF THE INVENTION

- 10 Wide area networks (WANs) that can be accessed wirelessly from homes and small offices are becoming increasingly popular. Such systems can offer a myriad of data services to subscribers including, for example, a relatively high speed connection to the Internet. Typically, a professional installation of transceiver and antenna equipment is required at the subscriber location to provide subscriber access to a WAN.
- 15 During the installation process, a technician must first determine an appropriate mounting location for an antenna unit on the exterior of the subscriber's building and then perform a relatively complex antenna aiming procedure to ensure that the antenna is properly directed toward the WAN base station antenna. Transceiver equipment is then installed and cabling is run from the external antenna location to the location of
- 20 the subscriber's communication equipment inside the building. This rather complicated setup procedure adds to the overall cost and complexity of providing WAN services and is relatively inefficient.

- Therefore, there is a need for a method and apparatus that allows simplified installation and setup of a wireless subscriber terminal for use with a WAN or similar
- 25 communication network. Preferably, the method and apparatus will allow a subscriber to perform the terminal setup without the need for a professional installer.

BRIEF DESCRIPTION OF THE DRAWINGS

- Fig. 1 is a block diagram illustrating a communication system in accordance
- 30 with one embodiment of the present invention; and

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Fig. 2 is a flowchart illustrating a method for use in maintaining a wireless link with a remote transceiver in accordance with one embodiment of the present invention.

DETAILED DESCRIPTION

5 The present invention relates to a wireless transmitter/antenna system that can be used by subscribers to achieve wireless access to a remote communication system or network. The system is relatively simple to install and can typically be setup by the subscriber alone without the assistance of a professional installer. In addition, because the system is easy to install and setup, it can be used in association with a portable data
10 processing device to provide wireless access to a remote system for a mobile user. The system can be used to support a wireless connection with any of a wide variety of different network types including: wide area networks (WANs), wireless local area networks (LANs), municipal area networks (MANs), public access networks (PANs), public switched telephone networks using wireless local loop, and others. The system
15 uses a beamforming or adaptive antenna arrangement that is capable of automatically generating a transmit beam in the direction of an external communication system base station or the like. The system is also capable of performing power control procedures to insure that transmit power in the system is adequate to penetrate, for example, the exterior walls of the subscriber's building and reach the external base station without
20 exceeding any government mandated power limits. In one approach, the system calculates the antenna gain of the main lobe of the generated antenna pattern using, among other things, the transmit beamformer parameters. This antenna gain information is then used to adjust the transmit power of the antenna so that the government mandated limit(s) are not exceeded. Other parameters, such as average
25 transmit duty cycle, can also be factored into the transmit power adjustment.

 In one embodiment of the invention, an indoor transmitter/antenna system is provided that can be made part of a complete desktop system using an integrated indoor antenna. The use of an indoor system simplifies the terminal installation process as complicated outdoor antenna placement and cabling tasks are avoided. An indoor
30 system, however, has to be able to generate enough transmit power to penetrate the exterior walls of the subscriber's building to enable communication with a remote base

station transceiver. In addition, an indoor system must comply with the FCC's standards for human exposure to electromagnetic radiation and the FCC imposed power limitations on individual spectrum bands. Other government imposed power limitations may also apply. To comply with these various requirements, the system of
5 the present invention utilizes power management techniques that are designed to optimize transmit power without exceeding existing power limits.

The FCC human exposure guidelines set a limit on the average transmit power that can be generated by a system over a predetermined time period (e.g., currently six minutes). Thus, a system that transmits for only a portion of each time interval can
10 utilize an instantaneous transmit power level that is greater than a system that transmits continuously. The increased power level will be inversely proportional to the duty cycle of the transmitter over that period. For example, a transmitter with an average duty cycle of 20% over a six minute period can generate a peak output power that is 5 times that of a system transmitting a continuous signal over that same period according
15 to the standard.

Fig. 1 is a block diagram illustrating an indoor communication system 10 in accordance with one embodiment of the present invention. The system 10 will typically be located within a subscriber's home or office for use in providing a wireless link to a remote transceiver, such as a WAN base station or the like. The system 10
20 includes an input 100 for receiving data to be transmitted to the remote transceiver (i.e., transmit data) from a data processing unit (e.g., a personal computer) at the subscriber location. The system 10 also includes an output 102 for outputting data received from the remote transceiver (i.e., receive data) to the local data processing unit. The communication system 10 will preferably be housed within one or two individual
25 housings that can be easily coupled to a personal computer or the like using standard interface techniques. For example, parallel or serial cables, Universal Serial Bus (USB) structures, coaxial cable, infrared coupling, PCMCIA cables, or other coupling techniques can be used. Alternatively, all or part of the communication system 10 can be located on an expansion card that can be inserted into an available slot of the data
30 processing unit. The interface can also include plug-and-play capability. In a typical setup procedure, the subscriber would couple the system 10 to the data processing unit

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using the appropriate coupling technique, install any necessary software to the data processing unit, power up the system 10, and run a setup program in the data processing unit.

As illustrated in Fig. 1, the communication system 10 includes: a transmit array 12, a transmit beamformer unit 14, a variable gain amplifier 16, a transmit signal generator 18, a power control unit 20, a duty cycle determination unit 22, a receive array 24, a receive beamformer 25, a direction determination unit 26, and a receiver 28. The receive array 24 is operative for receiving a radio frequency (RF) signal 36 from a remote transceiver (not shown) with which the system 10 is communicating. The receive array 24 includes a plurality of antenna elements that are arranged in a fixed configuration and that each receive a portion of the incoming signal 36. Each of the received signal portions are delivered to the receive beamformer 25 which combines the signal portions into a single RF receive signal for delivery to the receiver 28. The receiver 28 processes the RF receive signal to generate the receive data that is delivered to the local data processing unit via output 102. The receiver 28 can include, among other things, downconverter functionality, decoder functionality, and error detection/correction functionality.

The direction determination unit 26 analyzes the signals received by the elements of the receive array 24 to determine the direction from which the RF signal 36 was received. Techniques for determining the direction of an incoming RF signal are well known in the art. The direction determination unit 26 transfers the direction information to the transmit beamformer 14 which uses the direction information, along with knowledge of the array configuration of the transmit array 12, to generate a transmit beam in the direction of the remote transceiver. The newly generated transmit beam can then be used by the communication system 10 to transmit an RF transmit signal 38 to the remote transceiver.

The transmit signal generator 18 receives the transmit data from the local data processing unit and uses the data to generate an RF transmit signal for delivery to the remote transceiver. The transmit signal generator 18 will typically include a modulator for modulating an RF carrier signal using the input data. The transmit signal generator 18 can also include, among other things, a data encoder and/or error correction encoder

for encoding the input data before modulating the carrier. The variable gain amplifier 16 receives the RF transmit signal from the transmit signal generator 18 and amplifies the signal by a predetermined amount. The amplified transmit signal is then delivered to the transmit beamformer 14 which splits the signal into a number of components for delivery to the individual elements of the transmit array 12. The amplitudes and phases of the individual signal components delivered to the elements of the transmit array 12 by the transmit beamformer 14 determine the shape and direction of the resulting transmit beam.

The transmit array 12 can include virtually any number of antenna elements in accordance with the present invention. In addition, virtually any type of antenna element can be used, although low-profile, lightweight, less-expensive element types are preferred (e.g., microstrip patches or dipoles, etc.). Furthermore, virtually any array configuration can be used. The transmit beamformer 14 will typically include a separate variable delay unit and variable gain unit for each element of the transmit array 12. The transmit beamformer 14 will also preferably include a processing device that is programmed to determine appropriate settings for the variable gain and delay units to generate a relatively narrow transmit beam in the direction of the remote transceiver (using, e.g., well known phased array techniques).

By generating a relatively narrow beam in the direction of the remote transceiver, the available transmit power within the communication system 10 is concentrated in the direction of the remote transceiver. Thus, a higher power level is achievable for penetrating the exterior walls of the building than could be attained using an omni-directional transmit beam (or other wide beamwidth beam). In addition, because less power is wasted, a smaller power amplifier can be used in the communication system 10 which reduces equipment cost. As described above, however, the increased power level achieved by concentrating the available energy into a narrowed transmit beam must not exceed government imposed transmit power limits. As described in greater detail below, the power control unit 20 is operative for adjusting the power level currently being transmitted by the system 10 to insure that the applicable power limits are not exceeded.

variable gain units within the transmit beamformer 14 for use in adjusting transmit power.

In the illustrated embodiment, the direction determination unit 26 determines the direction of the remote transceiver by analyzing the signal components received by the individual elements of the receive array 24. It should be appreciated that the invention can utilize virtually any form of direction determination technique and is not limited to the above-described approach. In one embodiment, for example, global positioning system (GPS) equipment is used to determine the present position of the communications system 10 so that the distance and direction of the nearest WAN base station (or other remote transceiver) can be ascertained. As will be apparent to a person of ordinary skill in the art, other techniques for determining the direction of the remote transceiver also exist.

In one embodiment of the invention, the communication system 10 is implemented for use with a mobile or portable platform. Thus, a subscriber is able to move from place to place and still maintain a connection to, for example, a communication service provider. For example, a salesman can carry a laptop computer that includes or is coupled to a system 10 incorporating the principles of the present invention. When visiting a customer plant, for example, the salesman is able to perform an acquisition procedure, like the one described above, to connect the laptop computer to the nearest WAN base station for communicating with the salesman's home office. The communication system will generate a directed beam toward the base station and adjust the transmit power to comply with applicable limits. Similarly, the principles of the present invention can be implemented for use in mobile applications. In such an arrangement, an adaptive antenna beam will be used that remains directed at the applicable base station regardless of the movements of the associated user. In this approach, the gain of the main antenna beam will be continuously tracked and the power levels continuously adjusted in accordance therewith.

Fig. 2 is a flowchart illustrating a method for use in maintaining a wireless link with a remote communication entity using a beamformer antenna in accordance with one embodiment of the present invention. First, a desired transmit direction is determined (block 40). Next, a beamformer unit is configured to generate a transmit

antenna pattern that includes the desired transmit direction (block 42). The gain of the main lobe of the generated antenna pattern is then calculated based on the beamformer parameters (block 44). The average duty cycle of the transmit signal over a predetermined time interval is determined (block 46). The antenna gain and average
5 duty cycle information is then used to adjust the power transmitted by the antenna so that it does not exceed applicable limitations (block 48).

Although the present invention has been described in conjunction with certain embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention as those skilled in the
10 art readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and the appended claims.

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